REMARKS

Reconsideration of this application is respectfully requested in view of the foregoing amendments and discussion presented herein.

1. Rejection of Claims 1, 2, 7-11, 16, 18, 23, 28, 29, 34-38, 40, 41, 43, 45, 50, 55, 60, 61, 63, 64, 66, 67, 69, 71 and 76 under §102(b).

The Examiner has rejected Claims 1, 2, 7-11, 16, 18, 23, 28, 29. 34-38, 40, 41, 43, 45, 50, 55, 60, 61, 63, 64, 66, 67, 69, 71, and 76 under 35 U.S.C. § 102(b) as being anticipated by Zandveld (U.S. 4,104,085). Claims 1, 28 and 55 are independent.

In support of the rejection, the Examiner stated that Zandveld discloses the invention as claimed and describes,

> "A method for etching a substrate comprising; bombarding the surface of the wafer having a silicon (di)oxide layer with argon ions having energy of at least 20keV with the depth depending on the ions concentration and energy (claimed irradiating the wafer surface with a charged particle beam of suitable energy) and this would form claimed particle tracks; forming a pattern photoresist on the irradiated wafer surface; etching the wafer with a solution according to the etching pattern (col. 3, line 50-col. 4, line 50; figure 1-5)."

In response to the rejection, the Applicant has carefully considered the reference and the basis of the Examiner's rejection, and respectively traverses the Examiner's rejection on those grounds and submits that the invention is not anticipated by Zandveld as explained below.

(a) Claims 1, 28 and 55.

These claims recite the step of "irradiating the surface of a wafer with a charg d particle beam of suitabl energy to form particle tracks in said wafer"

(emphasis added). However, this element is not taught by Zandveld for purposes of §102 and, furthermore, there is no suggestion, motivation or incentive for this element for purposes of §103.

In Zandveld, "A first masking layer is (f)ormed on the surface," consisting of, "(S)ilicon (di)oxide (f)or example, by thermal oxidation," or, "(O)btained differently, for example by pyrolytic deposition." (col. 3, line 51-56). The next step is to subject this masking layer "(T)o a treatment as a result of which the layer shows at its surface a higher etching rate for an etching treatment to be used later in the process than in underlying parts of the layer." (col. 3, line 57-59). "For this purpose is advantageously used a particle bombardment, preferably a bombardment with ions of an inert gas. A bombardment with argon ions proves to be very suitable in this respect." (col. 3, line 61-64). This bombardment of argon ions on the silicon (di)oxide layer is a surface treatment that causes a gradient of radiation damage through the layer resulting in higher etching rates near the surface of the layer than in the underlying parts of the layer. There is no disclosure of the formation of particle tracks as a result of this bombardment in Zandveld.

In the Applicant's claims, however, particle tracks are formed in the wafer. This is explained in the specification as follows: "(T)he method begins by irradiating (the) wafer (w)ith an energetic charged particle beam of predetermined collimation and direction with respect to the surface of the wafer" (specification, page 8, lines 18-21). "The passage of particles through the material generates a strong electromagnetic field that breaks chemical bonds within its immediate

vicinity along the p rticle tracks" (specification, page 8, line 21-22, emphasis added). "The line of the radiation-damaged material can then be preferentially etched by suitable chemical solutions, thus providing the mechanism of particle-track-guided etching" (specification, page 10, line 1-3, emphasis added). The formation of etchable particle tracks in the wafer by the energetic charged particle beam is patently different from the localized surface radiation damage created by ion bombardment used to produce a gradient of etching rates in Zandveld.

Further support for the Applicant's assertion that formation of particle tracks is not taught by Zandveld is provided by the fact that the starting material in Zandveld is "(A)n n-type conductive silicon plate," (col. 3, line 43) or an "n-type silicon layer" (col. 3, line 49). In the Applicant's invention, however, "Etchable tracks can be formed in bulk inorganic crystals, and certain glasses and high polymers" (specification, page 9, line 7). "The materials must be insulators or weak semiconductors," (specification, page 9, line 8-9), "Preferred materials (i)nclude quartz crystals, silica glasses and mica" (specification, page 9, line 12). The specification further states, "Therefore, metals or silicon (w)ould not typically be suitable materials for particle (track) etching" (page 9, line 10, emphasis added).

It is clear that Zandveld does not teach the step of irradiating the surface of a wafer with a charged particle beam of suitable energy to form particle tracks in the wafer as recited in the Applicant's claims. Therefore, since independent Claims 1, 28 and 55 recit one or more elements not taught by the cited

reference, thos claims, as well as the claims that depend therefrom, ar not anticipated for purposes of 35 U.S.C. § 102(b). Furthermore, based on what Zandveld does teach, it is clear that Zandveld does not suggest or provide motivation or incentive for the elements recited in the subject claims for purposes of 35 U.S.C. §103.

(b) Claims 2, 10, 29, 37, 38, 55, 63, 64.

The Examiner further states "Referring to claims 2, 10, 29, 37, 38, 55, 63, 64, figure 2 shows the charged particle beam is of predetermined collimation and at a desired direction (perpendicular) with respect to the wafer surface."

In response, Applicant refers to the arguments set forth above in support of patentability of Claims 1, 28 and 55. Since Claims 1, 28 and 55 are allowable, Claims 2, 10, 29, 37, 38, 55, 63, and 64 which depend from Claims 1, 28 and 55 are, *a fortiori*, be allowable.

In addition, Claims 2, 29 and 55 include the further limitation, "(W)herein said charged particle beam is directed to said surface of said wafer with a predetermined collimation at a desired direction." In this regard, the Applicant respectfully submits that the predetermined collimation or alignment of the particle beam in the present invention provides beneficial advantages and is patently distinct from the bombardment of ions in Zandveld.

Zandveld states "FIGS. 1 to 7 are diagrammatic cross-sectional views of a semiconductor device according the invention in successive stages of manufacture" (column 3, line 29-31 emphasis added). "In this example a bombardment with argon ions (arrows 4) (i)s used," (col 3, line 64-67 emphasis

added). The bombardment of ions produces a gradi nt of radiation damage through a surface layer. The parallel arrows 4 in Figure 2 are diagrammatic or representative of an ion bombardment only and do not teach a predetermined collimated ion beam.

It is clear that Zandveld Is silent on the particle beam bombardment to be collimated. Therefore, Claims 2, 10, 29, 37, 38, 55, 63, and 64 recite one or more elements that are not found in Zandveld. Accordingly, those claims, as well as the claims that depend therefrom, are patentably distinct over Zandveld.

Furthermore, the subject matter of these claims is not rendered obvious by Zandveld. The collimation and orientation of the particle beam determine the precision and direction of the etch pattern through the body of the wafer. This is a beneficial advantage that is not achieved by Zandveld. There is nothing in Zandveld that provides any suggestion, motivation or incentive for this element for purposes of §103.

(c) Claims 10, 37 and 63.

Claims 10, 37 and 63 include the further limitation, "Wherein said irradiating of said wafer comprises placing said wafer in said particle beam in a desired direction with respect to the wafer surface." As explained above, the orientation of the particle beam with respect to the wafer surface in the present invention is not taught by, and is not obvious in view of, Zandveld's teachings of bombardment of ions with a non-specific collimation.

Therefore, the subject matter of Claims 10, 37 and 63 is not anticipated nor rend red obvious by Zandveld.

(d) Claims 11, 38 and 64.

Claims 11, 38 and 64 include the further limitation, "Wherein said desired direction is perpendicular to the wafer surface." As explained above, the orientation of the particle beam with respect to the wafer surface in the present invention is not taught by, and is not obvious in view of, Zandveld's teachings of bombardment of ions with a non-specific collimation. Furthermore, formation of particle tracks perpendicular to the wafer surface results in beneficial particle track etching that is perpendicular to the wafer surface and is patentable over Zandveld.

Therefore, the subject matter of Claims 11, 28 and 64 is not anticipate or rendered obvious by Zandveld.

2. Rejection of Claims 1-4, 7, 8, 10, 14, 16, 18, 28-31, 34, 35, 37, 41, 43, 45, 55-57, 60, 61, 63, 67, 69 and 71 under §102(e).

The Examiner has rejected Claims 1-4, 7, 8, 10, 14, 16, 18, 28-31, 34, 35, 37, 41, 43, 45, 55-57, 60, 61, 63, 67, 69, and 71 under 35 U.S.C. § 102(e) as being anticipated by Liu et al. (U.S. 6,271,127). Claims 1, 28 and 55 are independent.

In support of the rejection, the Examiner stated that Liu et al. discloses the present invention as claimed and describes,

> "A method for forming dual damascene comprising: exposing the substrate surface with and (sic) electron beam or ion implantation with suitable energy (claimed irradiating the wafer surface with a charged particle beam of suitable energy) and this would form claimed particle tracks with a desired depth and alignment; d positing and d veloping a resist to form an tching pattern on th

wafer (claimed depositing and removing portions of th resist layer to generate an etching pattern on th wafer); etching the wafer according to the etching pattern (col. 7, line 21-44; col. 8, line 20-30)."

In response to the rejection, the Applicant has carefully considered the reference and the basis of the Examiner's rejection, and respectively traverses the Examiner's rejection on those grounds and submits that the invention is not anticipated by Liu et al. as explained below.

(a) Claims 1, 28 and 55.

Claims 1, 28 and 55 recite "A method for nanomachining a precise structure, comprising:

irradiating the surface of a wafer with a charged particle beam of suitable energy to form particle tracks in said wafer." (Claims 1, 28 and 55, emphasis added). The formation of particle tracks in the wafer is patentably distinct from the teachings Liu et al. as explained below.

In Liu et al., a semiconductor substrate receives a deposition of a first layer of a low dielectric constant material (col. 6, line 37-45). This first layer is then cured on the substrate by exposure to either, "(E)lectron beam irradiation and rapid thermal heating, or ion implantation, which involves both ion implantation and rapid thermal heating." (col. 6, line 45-50). Exposure of the first (l)ayer to an electron beam results in the conversion of the topmost layer of the first (l)ayer into a first hard mask or etch stop while rapid thermal heating associated with electron beam exposure cures the remainder of the first (l)ayer so it obtains its low dielectric constant properties." (col. 6, line 50-57). The ion

implantation and rapid thermal heating in Liu et al. cures the first layer of mat rial into a hard mask or etch stop. (col. 6, line 57-61).

In the present invention, on the other hand, the wafer is irradiated with a charged particle beam of suitable energy to form particle tracks in said wafer. By way of explanation, the wafer (substrate) is first "(I)rradiated with a particle beam of suitable energy to break the chemical bonds of the material," (page 5, line 15-16). "This step produces particle tracks for guiding the high aspect ratio nano-machining by particle track etching that will take place in a later processing step." (page 5, line 18-19).

In contrast, Liu et al. does not teach ion implantation of suitable energy for the formation of etchable particle tracks in the first layer or the substrate. Liu et al. also does not disclose or suggest a wafer material suitable for the formation of particle tracks.

It is clear that Liu et al. does not teach the step of irradiating the surface of a wafer with a charged particle beam of suitable energy to form particle tracks in the wafer as recited in the Applicant's claims. Therefore, since independent Claims 1, 28 and 55 recite one or more elements not taught by the cited reference, those claims, as well as the claims that depend therefrom, are not anticipated for purposes of 35 U.S.C. § 102(b). Furthermore, based on what Liu et al. does teach, it is clear that Liu et al. does not suggest or provide motivation or incentive for the elements recited in the subject claims for purposes of 35 U.S.C. §103.

(b) Claims 2, 10, 39 37, 55 and 63

The Examiner further states "Referring to claims 2, 10, 29, 37, 55, 63, even though Liu is silent about the charged particle beam is of predetermined collimation and at a desired direction with respect to the wafer surface, the electron beam or ion implantation would have to carry a certain collimation and at a certain direction (claimed predetermined collimation at a desired direction) with respect to the wafer surface."

In response, Applicant first relies upon the arguments set forth above in support of Claims 1, 28 and 55 above. For the same reasons that Claims 1, 28 and 55 are allowable, Claims 2, 10, 29, 37, 55, and 63 which depend from Claims 1, 28 and 55 are *a fortiori* allowable.

Furthermore, in Liu, a thin layer is irradiated by an electron beam or ion implantation for curing the surface of the layer. There is no requirement or advantage disclosed in Liu for a collimated beam or a beam originating at a particular direction relative to the surface of the layer. In the present invention, the precision of the pattern etching along the particle tracks in the wafer body is a function of the alignment of the particle tracks, which is a function of the degree of collimation of the particle beam. There are beneficial advantages to close alignment of the particle tracks as provided by the predetermined collimation and desired direction of the particle beam and these advantages are patently distinct from the irradiation without reference to collimation in Liu et al.

Therefore, it is clear that not only are the subject claims not anticipated by Liu et al. under §102(e), but Liu et al. does not suggest or provide motivation or incentive for the subject matter of those claims for purposes of §103.

(c) Claims 14, 41, and 67.

The Examiner states, "Claims 14, 41, 67 do not have patentable weight because it is an optional limitation." The Applicant does not understand this ground of rejection and, furthermore, submits that it is not a proper ground for rejection. Any limitation in a claim is to be given weight whether optional or not and the Examiner has not shown that Liu et al. teaches, suggests or provides motivation or incentive for the invention recited in those claims.

Furthermore, these claims are patentable for the reasons that their base claims are patentable.

3. Rejection of Claims 9, 11, 13, 36, 38, 40, 62, 64, and 66 under §103.

The Examiner has rejected Claims 9, 11, 13, 36, 38. 40, 62, 64, 66 under 35 U.S.C. 103(a) as being unpatentable over Liu et al. as applied to Claims 1, 10, 28, 37, 55, 63 above, and further in view of Zandveld for the following stated reason:

> "The ion implantation taught by Liu is known to one skilled in the art. Zandveld describes such ion implantation method using argon ions (col. 3, line 64-68). This would read on claimed charged particle beam is produced by removing some or all electron from neutral atoms. Method, such as using an accelerator, to produce such ions are known by one skilled in the art as shown in page 9, line 1 -2 of specification."

In response to the rejection, the Applicant has carefully considered the reference and the basis of the Examiner's rejection. The Applicant respectively traverses the Examiner's rejection of the aforementioned claims on the above grounds and submits that the invention is not rendered obvious by the combined teachings of Liu et al. and Zandveld.

The subject claims, through their dependency, recite "irradiating the surface of a wafer with a charged particle beam of suitable energy to form particle tracks in said wafer" (emphasis added). As explained above, neither Zandveld nor Liu et al. provide any suggestion, motivation or incentive for this aspect of the Applicant's invention. More particularly, neither Zandveld nor Liu et al. suggest or provide motivation or incentive for using a charged particle beam of suitable energy to form particle tracks. Further, neither Zandveld nor Liu et al. even suggest or provide motivation or incentive for using a wafer material suitable for the formation of particle tracks.

Therefore, the Applicant respectfully submits that Claims 1, 28 and 55, as well as well as the claims that depend therefrom, are not rendered obvious by the combined teachings of Zandveld and Liu et al. for purposes of 35 U.S.C. § 103(a). Accordingly, Claims 9, 11, 13, 36, 38, 40, 61, 64 and 66 which depend therefrom, are not obvious in view of the cited combination.

4. Rejection of Claims 15, 17, 19-22, 42, 44, 46-49, 68, 70, 72-75 under 35 U.S.C. 103(a).

The Examiner has rejected Claims 15, 17, 19-22, 42, 44, 46-49, 68, 70, 72-75 under 35 U.S.C. 103(a) as being unpatentabl over Liu et al. or Zandveld

as appli d to Claims 1, 28, 55 abov , and further in vi w of Hashimoto et al. (US 4,976,818).

In response, the Applicant refers to the arguments set forth above in support of nonobviousness of Claims 1, 28 and 55 with regard to the combined teachings of Liu et al. and Zandveld. Furthermore, there is nothing in Hashimoto et al. that, when combined with Liu et al. and Zandveld, causes the combination to suggest, teach or provide motivation or incentive for "irradiating the surface of a wafer with a charged particle beam of suitable energy to form particle tracks in said wafer" as recited in the rejected claims. Therefore, the Applicant respectfully submits that the subject claims are patentable over the cited combination.

5. Rejection of Claims 23-25, 50-52 and 76-78 under 35 U.S.C. 103(a).

The Examiner has rejected Claims 23-25, 50-52 and 76-78 under 35 U.S.C. 103(a) as being unpatentable over Liu et al. as applied to Claims 1, 28, 55 above, and further in view of what the Examiner asserts is Applicant's admitted prior art.

In response, the Applicant refers to the arguments set forth above in support of nonobviousness of Claims 1, 28 and 55 with regard to the teachings of Liu et al. Furthermore, there is nothing in the so-called admitted prior art that, singly or when combined with Liu et al., causes the combination to suggest, teach or provide motivation or incentive for "irradiating the surface of a wafer with a charged particle beam of suitable energy to form particle tracks in said wafer"

as recited in the r jected claims. Therefore, the Applicant respectfully submits that the subject claims are patentable over the cited combination.

6. Rejection of Claims 5, 6, 26, 27, 32, 33, 53, 54, 58, 59, 79 and 80 under 35 U.S.C. 103(a).

The Examiner has rejected Claims 5, 6, 26, 27, 32, 33, 53, 54, 58, 59, 79 and 80 under 35 U.S.C. 103(a) as being unpatentable over Liu et al. or Liu et al. /admitted prior art as applied to Claims 1, 25, 28, 52, 57, and 78 above, and further in view of Chen (U.S. 5,723,387).

In response, the Applicant refers to the arguments set forth above in support of nonobviousness of Claims 1, 28 and 55 with regard to the combined teachings of Liu et al. and Liu et al./admitted prior art. Furthermore, there is nothing in Chen that, singly or when combined with Liu et al. and Zandveld, causes the combination to suggest, teach or provide motivation or incentive for "irradiating the surface of a wafer with a charged particle beam of suitable energy to form particle tracks in said wafer" as recited in the rejected claims. Therefore, the Applicant respectfully submits that the subject claims are patentable over the cited combination.

7. Rejection of Claims 12, 39 and 65 under 35 U.S.C. 103(a).

The Examiner has rejected Claims 12, 39 and 65 under 35 U.S.C. 103(a) as being unpatentable over Liu et al. or Zandveld as applied to Claims 10, 37, and 63 above.

In response, the Applicant refers to the arguments set forth above in support of nonobviousness of Claims 1, 28 and 55 with regard to the combined

teachings of Liu t al. and Zandveld. There cited combination does not suggest, teach or provide motivation or incentive for "irradiating the surface of a wafer with a charged particle beam of suitable energy to form particle tracks in said wafer" as recited in the rejected claims. Therefore, the Applicant respectfully submits that the subject claims are patentable over the cited combination.

8. Rejection of Claims 23, 50 and 76 under § 112, second paragraph.

Examiner has rejected Claims 23, 50 and 76 under 35 U.S.C. §112, second paragraph as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

More specifically, the Examiner states "The limitation "etching pattern ... with aspect ratio substantially greater than that in etching pattern" is vague and unclear to what exactly being compared."

In response, Applicant has amended the last element of Claims 23, 50 and 76 to read: "wherein, said etching pattern is partially or completely transferred to the wafer and the aspect ratio of the etched portion of said wafer to that of said etched pattern is substantially greater than one."

In view of the amendment above, Applicant believes that these grounds for rejection have been sufficiently addressed and overcome, and respectfully requests reconsideration and withdrawal of these grounds for rejection.

9. Conclusion.

In view of the above, each of the presently pending claims in this application is believed to be in immediate condition for allowance. Accordingly, the Examiner is respectfully requested to withdraw the outstanding rejection of

th claims and to pass this application to issue.

The Applicant also respectfully requests a telephone interview with the Examiner in the event that there are questions regarding this response, or if the next action on the merits is not an allowance of all pending claims.

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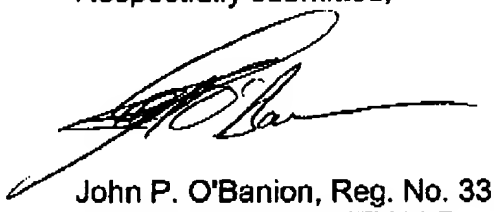
Respectfully submitted,



John P. O'Banion, Reg. No. 33,201
O'BANION & RITCHEY LLP
400 Capitol Mall, Suite 1550
Sacramento, CA 95814
(916) 498-1010